International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 8, Issue 3, Jun 2018, 549-556


# EXPERIMENTAL INVESTIGATION OF TENSILE AND IMPACT BEHAVIOUR OF HEMP FLAX HYBRID COMPOSITE

**S. SHARAVANAN[1], B. VIJAYA RAMNATH[2], C. ELANCHEZHIAN[3] & S. RAJESH[4]**

[1]*Research Scholar, Department of Mechanical Engineering, Vels Institute of Science, Technology and Advanced Studies (VISTAS), Chennai, Tamil Nadu, India*

[2,3]*Professor, Department of Mechanical Engineering, Sri Sairam Engineering College, Chennai, Tamil Nadu, India*

[4]*Assistant Professor, Department of Mechanical Engineering, Sri Sairam Engineering College, Chennai, Tamil Nadu, India*

***ABSTRACT***

***Developments in Engineering and Technology urging the need to identify and improve a wide variety of materials using the natural fiber. Composite plays a vital role in manufacturing and defense industries. In this work, Natural fiber, namely Hemp and flax are used as reinforcement along with epoxy resins to enhance Mechanical properties. These fibers are used because of easy extraction methods and more economical. In this research work, hemp and flax composites are prepared using hand lay-up method as mono, and hybrid composites. Various mechanical tests have been carried out to determine the mechanical characteristic of the composite laminate and the results are compared.***

***KEYWORDS: Hemp Fiber, Flax Fiber, Hybrid Composite, Hand Lay-up Process & Testing***

**Received:** Apr 07, 2018; **Accepted:** Apr 28, 2018; **Published:** May 18, 2018; **Paper Id.:** IJMPERDJUN201859

Original Article

## INTRODUCTION

Composites are preferred due to their high Strength to Weight ratio, eco-friendly and biodegradable environments. In the modern engineering industries, various materials are replaced by composite materials because of less weight and high durability. Mondher Haggui et al (1) investigated the characterization of flax fiber reinforced thermoplastic composites by acoustic emission. Here, the thermoplastic composites are characterized by static and fatigue loading. These composites were prepared by liquid resin infusion. Initially, tensile tests were done because of the inclusion of natural fiber exhibits nonlinear behavior in the structure. Then, the cyclic tensile tests and fatigue tensile test behavior was studied by macroscopic damage and material stiffness degradation. They concluded that the acoustic behavior was classified as four classes such as the matrix micro-cracking, the fiber-matrix deboning, the fiber pulls out and the fiber breakage. From this class, the flax/helium composite showed better performance in unidirectional configuration than the composites of cross- ply. Jianxing Hu et al (2) investigated on the woven flax-epoxy composites and their dynamic compressive behavior. The composites were fabricated by using vacuum-assisted resin infusion. In-plane and out-of- plane compressive behavior was studied when subjected to test from quasi to dynamic loading. From the strain rate sensitivity, they concluded that there was the ultimate stress and specific energy absorption for in-plane loading increased by 49.6% and 30.4%, respectively. Lut Pil et al (3) gave insight about why flax and hemp are the designer's first choice. They found that these composites show higher specific stiffness than glass fiber composites in tension and plate bending, higher vibration damping capacity. They provided technical aspects such as mechanical properties and non-technical aspects such as feel, touch, colour

and texture of the fibers and their influence on the daily purpose items and the designers' choice of selecting these fibers. Zia Mahboob et al (4) investigated on the tensile and compressive damage response of flax reinforced epoxy composites. The damage response of this fiber was studied by SEM images. The data are obtained by inducing repetitive loading-unloading of the specimens and measuring the stiffness and permanent deformation that happened. From the results, they concluded that the damages manifests as accumulated strain and degrading modulus. Ming Liu et al (5) investigated on the effects on mechanical properties of hemp fibers and unidirectional fiber/epoxy composites. These effects were studied when the hemp fibers were oxidized of lignin by laccase. The oxidized fibers were taken to study its mechanical properties such as tensile stress, thermal resistance, etc. From the results, they concluded that there was an increase in tensile stress, stiffness and thermal resistance of the laccase treated fibers. There was no cross-linking by laccase was seen. This increase in properties was due to the catalyzed polymerization of lignin in hemp fibers. Charlotte Campana et al (6) investigated behavior of the flax fiber reinforced epoxy composite at post curing temperature. The properties of composites were found to be unchanged until the post-curing temperature reaches 150 degree Celsius. The composite, glass transition temperature and cross-linking rate increases when post-cure is carried out. They also found that the properties decreased drastically while the specific modulus increases. The authors concluded that this drastic decrease of properties can be reduced by employing the resin that could be cured at low temperature rapidly and the flax fibers are most sensitive to thermal treatment. Sair et al (7) investigated on the Characterization with the interface of hemp –Polyurethane composite. The characterization was done based on the Effect of surface modification on the morphological, mechanical and thermal conductivity of hemp fiber. Hemp fibers were treated with sodium hydroxide solutions at varied concentration, and then analyzed by infrared Fourier transform spectroscopy, the X-ray diffraction, mechanical tensile test; and a scanning electron microscope. The same treated with silane and analyses were carried out. From the results, the authors found that the alkali treatment induced some modifications on the fiber composite such as removal of lignin, wax. This eventually increases the tensile strength and Young's modulus. It also increases the thermal conductivity of the treated composites. Vijaya Ramnath et al (8, 9, and 10) investigated various mechanical test in various natural fibers and found that the hybrid composites has better mechanical properties and also it was observed that it can be used as the alternate material for various automobile and defense applications. Srinivasan et al (11,12) investigated flax-kenaf hybrid composite behaviour, and found that the increment in kenaf content increases strength. Manickavasagam et al (13, 14) determined flax –abaca fiber composites behavior and found that mechanical properties have been found significant.

## MATERIALS USED

### Hemp Fiber

**Figure 1: Hemp Fiber**

Hemp fiber shown in Figure 1 is the bast fiber which consists of long, soft and shiny fiber. It can be spun into a number of turns to make it as coarse. It is very economical and easy to fabricate. Hemp fibers consist of high cellulose, pectin and lignin content which increases its tensile strength. It is biodegradable and eco-friendly. It is used in various

textile machineries, bags, upholstery and home furnishings.

**Flax Fiber**

**Figure 2: Flax Fiber**

Among natural cellulosic fibers, flax fibers shown in Fig.2 are one of the strongest fibers. It can be extracted from the stem of the flax plant which is a soft and flexible fiber. It is used to make the clothes expensive for comfortable wearing. It can also be used to make composites for automotive industries as reinforcements.

**Glass Fiber Reinforced Polymer**

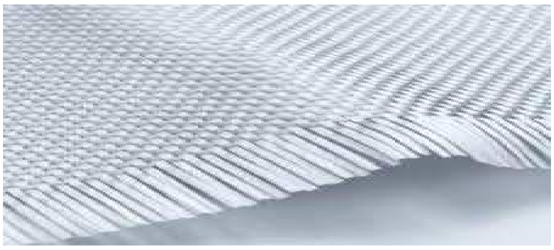

**Figure 3: Glass Fiber Reinforced Polymer**

It is a the strongest fiber arranged in a random manner which is then flattened into the sheet of woven like structure. It can be of either thermoplastics or thermosetting plastics. Because of high strength in both the tension and compression, it can be used as layering in multiple sequences so as to increase the strength of composites. Mostly epoxy resin is used as matrix material for GFRP composite. Fig. 3 shows GFRP composite.

## FABRICATION PROCEDURE

In this work, hard layup process is implemented to fabricate the laminate. Both Hemp and flax fibers are dried in sunlight for 24 hours after retting process is completed. Then, the fibers are combed into straight layers, thereby for achieving straight flakes for the easy purpose of layering sequentially for forming the composite laminate. In this work, Epoxy resin and hardener HY951 are used as the matrix medium. Initially, some releasing agents can be poured on the table for easy removal of the laminate after completing the process. Firstly, then GFRP is used as the enclosure for both the sides as it closes with layers of fibers. Hence GFRP is layered as the bottom most first sequence and then the rollers are set to be rolled over the surface thoroughly to remove the sprinkles on the sheet. Then the Hemp fibers are placed in the horizontal direction in a stipulated setting time of resin hardener mixture. Again the resin-hardener is poured over the Hemp fiber. Then, the flax fibers are placed horizontally and it is in a systematic manner as that of Hemp fiber and it is packed as per the required dimensions of the composite laminate and the process is repeated up to 6 layers of alternate Hemp and flax fibers. Finally, GFRP is placed to close the bottom-most layer. The laminate is compressed to 1

mm thick and by placing the weight uniformly over the entire surface of the laminate. Similarly, the fabrication is repeated for other categories as mentioned in the Table1. The schematic representation of the preparation of all categories is shown in Table1.

**Table 1: Arrangement of Fibers**

| CATEGORY 1 | CATEGORY II | CATEGORY III |
|---|---|---|
| **Hemp Composite** | **Flax Composite** | **Hybrid Composite** |
| Hemp Fiber ($0^o$) | Flax Fiber ($0^o$) | Hemp Fiber ($0^o$) |
| Hemp Fiber ($90^o$) | Flax Fiber ($90^o$) | Flax Fiber ($90^o$) |
| Glass Fiber | Glass Fiber | Glass Fiber |
| Hemp Fiber ($45^o$) | Flax Fiber ($45^o$) | Hemp Fiber ($45^o$) |
| Glass Fiber | Glass Fiber | Glass Fiber |
| Hemp Fiber ($90^o$) | Flax Fiber ($90^o$) | Flax Fiber ($90^o$) |
| Hemp Fiber ($0^o$) | Flax Fiber ($0^o$) | Hemp Fiber ($0^o$) |

## TESTING OF COMPOSITES

Tensile and impact test wear conducted. In each category, 3 samples were tested.

### Tensile Test

A universal testing machine is used for tensile testing. ASTM D638 standard is used for preparing the specimen as shown in Figure 4. Three categories of the specimen are subjected to a tensile test with a maximum of 300 kgf load capacity. The specimen is held in between the grips and the load is applied continuously until the specimen breaks and the corresponding values are recorded. The ultimate tensile strength and break load are  recorded for each specimen.

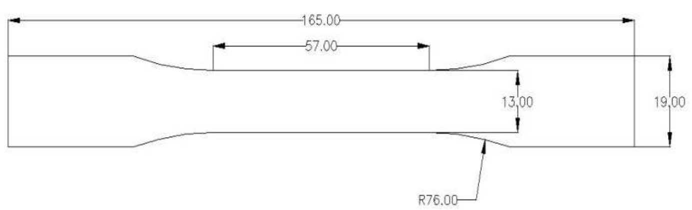


**Figure 4: Schematic diagram of Tensile Test Specimen [ASTM: D638]**

### Impact Test

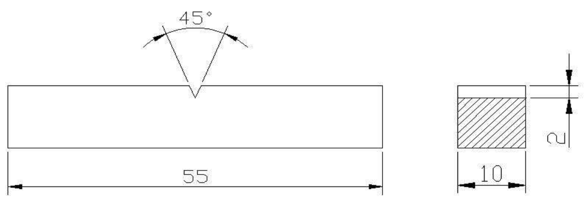


**Figure 5: Impact Test Specimen**

To find impact strength, charpy impact test machine was used. In this test, the pendulum is dropped from an angle and the specimen fractures at a particular point. The amounts of energy absorbed were noted. The specimen is prepared as per ASTM: D256 standard.

## RESULTS AND DISCUSSIONS

### Results of Tensile Test

The results of a tensile test of three samples with hemp and flax fibers were tabulated in Table 2. The tensile test was carried out in the universal testing machine and the graphs have been plotted as shown in figure 6 and 7.

**Table 2: Results of Tensile Test**

| Sl. No | Category | Samples | Ultimate Tensile Load (kN) | Average | Ultimate Tensile Strength ($N/mm^2$) | Average |
|---|---|---|---|---|---|---|
| 1 | C1 | S1 | 2.18 | 2.4 | 31.00 | 34 |
| | | S2 | 2.54 | | 36.00 | |
| | | S3 | 2.52 | | 34 | |
| 2 | C2 | S1 | 3.79 | 2.96 | 22.00 | 18 |
| | | S2 | 2.77 | | 17.00 | |
| | | S3 | 2.33 | | 15.00 | |
| 3 | C3 | S1 | 2.90 | 3.2 | 37.00 | 38 |
| | | S2 | 3.41 | | 40.00 | |
| | | S3 | 3.29 | | 38.00 | |

### Comparison of Ultimate Tensile Load in kN for Tensile Test

Figure 6 Shows a  comparison of ultimate an tensile load of 3 category of composites. It was observed that hybrid composite (Category III) absorbs more load as compared to other two categories.

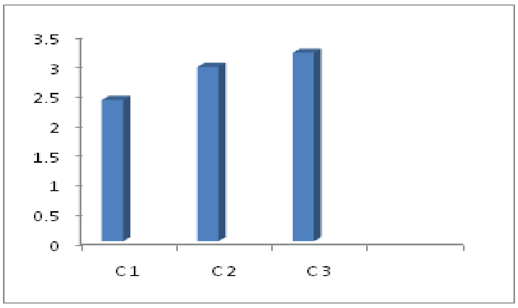


**Figure 6: Consolidated results of Ultimate Tensile Load (kN)**

### Comparison of Ultimate Tensile Strength Composites

Figure 7 shows the result of tensile test of three categories with hemp and flax fibers. It was observed that hybrid composite (Category III) has more ultimate tensile strength compared to other two categories.

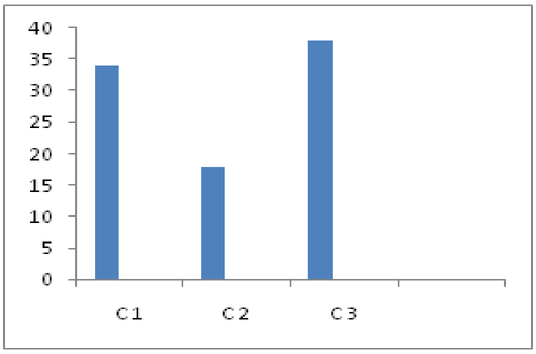


**Figure 7: Consolidated results of Ultimate Tensile Strength (MPa)**

**Results of Impact Test**

Table 3 shows the results of impact test of three categories with hemp and flax fibers. The impact test was carried out with charpy machine and the corresponding graphs have been plotted. In the graphs plotted for energy absorbed in joules, category II recorded high value of 4J when compared to other categories I and III since it contains flax fiber alone. The Fig. 8 shows the consolidated results of impact strength of all categories.

**Table 3:Results of Charpy Impact Test**

| Sl. No | Category | Samples | Energy Absorbed (J) | Average (J) |
|---|---|---|---|---|
| 1 | C1 | S1 | 2 | 2 |
| | | S2 | 2 | |
| | | S3 | 2 | |
| 2 | C2 | S1 | 4 | 4 |
| | | S2 | 4 | |
| | | S3 | 4 | |
| 3 | C3 | S1 | 2 | 2 |
| | | S2 | 2 | |
| | | S3 | 2 | |

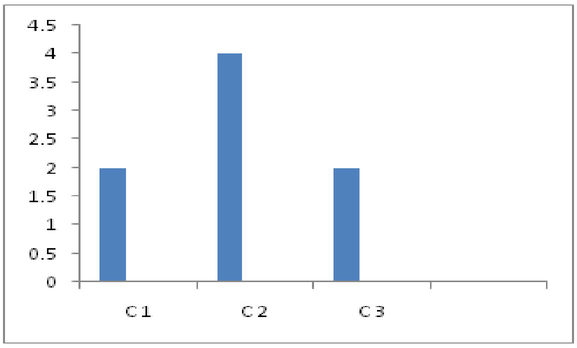


**Figure 8: Consolidated results of Impact Test (J)**

## CONCLUSIONS

Mechanical Tests such as tensile and impact test was done for various samples of different categories. The results were recorded and the corresponding graphs have been plotted. The conclusions of various tests will be as follows.

For ultimate tensile load, category II of sample 1 recorded high value of 3.79kN when compared to other categories I and III. For ultimate tensile strength, category I of sample 2 recorded high value of 36MPa when compared to other categories II and III. For energy absorbed in joules, category II recorded high value of 4J when compared to other categories I and III. This material can be used in automobile industries as the replacement for metals to reduce the weight with appropriate strength.

***REFERENCES***


1. *Mondher Hagguia, Abderrahim El Mahia, Zouhaier Jendli, Ali Akrout, Mohamed Haddar," Static and fatigue characterization of flax fiber reinforced thermoplastic composites by acoustic emission", Applied Acoustics (2018),https://doi.org/10.1016/j.apacoust.2018.03.011*

2. *Jianxing Hua, Sha Yina, T. X. Yu, Jun Xu," Dynamic compressive behavior of woven flax-epoxy-laminated composites", International Journal of Impact Engineering 117 (2018) 63–74*

3. *Lut Pil, Farida Bensadoun, Julie Pariset, Ignaas Verpoest,"Why are designers fascinated by flax and hemp fibre composites?"Composites: Part A 83 (2016) 193–205.*

4. *Zia Mahboob, Ihab El Sawi, Radovan Zdero, Zouheir Fawaz, Habiba Bougherara," Tensile and compressive damaged response in Flax fibre reinforcedepoxy composites", Composites: Part A 92 (2017) 118–133.*

5. *Ming Liu, Andreas Baum, Jürgen Odermatt, Jens Berger, Liyun Yu, Birgitte Zeuner, Anders Thygesen, Jesper Holck, Anne S. Meyer,"Oxidation of lignin in hemp fibres by laccase: Effects on mechanical properties of hemp fibres and unidirectional fibre/epoxy composites", Composites: Part A 95 (2017) 377–387.*

6. *Charlotte Campana, Romain Leger, Rodolphe Sonnier, Laurent Ferry, Patrick Ienny," Effect of post curing temperature on mechanical properties of a flax fiber reinforced epoxy composite", Composites: Part A 107 (2018) 171–179.*

7. *S. Sair, A. Oushabi, A. Kammouni, O. Tanane, Y. Abboud, F. Oudrhiri Hassani,A. Laachachi, A. El Bouari," Effect of surface modification on morphological, mechanical and thermal conductivity of hemp fiber: Characterization of the interface of hemp –Polyurethane composite", Case Studies in Thermal Engineering 10 (2017) 550–559.*

8. *Pawar, Aman S., and Abhishek Gaikwad. "Evolution of A New Hybrid Bio Composite and Evaluation of its Mechanical Properties."*

9. *Vijaya Ramnath, B. S. Rajesh, C. Elanchezhian, A. Santosh Shankar, S. Pithchai Pandian, S. Vickneshwaran, and R. Sundar Rajan, "Investigation on Mechanical Behaviour of Twisted Natural Fiber Hybrid Composite Fabricated by Vacuum Assisted Compression Molding Technique", Fibers and Polymers 2016, Vol.17, No.1, 80-87.*

10. *Vijaya Ramnath B., C. Elanchezhian, P. V. Nirmal, G. Prem Kumar, V. Santhosh Kumar, S. Karthick, S. Rajesh, and K. Suresh, "Experimental Investigation of Mechanical behavior of Jute-Flax Based Glass Fiber Reinforced Composite", Fibers and Polymers 2014, Vol.15, No.6, 1251-1262.*

11. *B. Vijaya Ramnath, C. Elanchezhian, C. V. Jayakumar, V. M. Manickavasagam, U. S. Aswin, H. Eashwar, P. Kavirajan, D. Murugan," Investigation of Flexural Characteristics of Flax and Abaca Hybrid Epoxy Composites', Applied Mechanics and Materials, Vols. 766-767, pp. 183-186, 2015.*

12. *VS Srinivasan, S Rajendra Boopathy, B Vijaya Ramnath," Fabrication and evaluation of tensile properties of kenaf-flax hybrid composite," Applied Mechanics and Materials 680, 50-53.*

13. *VS Srinivasan, S Rajendra Boopathy, B Vijaya Ramnath, "Investigation on shear behaviour of flax-kenaf hybrid composite", Advanced Materials Research 1051, 139-142.*

14. *VM Manickavasagam, B Vijaya Ramnath, C Elanchezhian, "Investigation of Tensile Behaviour of Flax–Abaca Hybrid Epoxy Composite",Applied Mechanics and Materials 766, 140-143.*

15. *VM Manickavasagam, B Vijaya Ramnath, C Elanchezhian, R Sundarrajan, "Evaluation of the Double Shear and Hardness of Abaca and Flax Reinforced Polymer Composite for Automotive Applications', Applied Mechanics and Materials 766, 85-89.*